Heavy metals assessment of wastewater in peri-urban locations of Faisalabad District

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Abstract- Wastewater disposal is a very important ecological, environmental and social concern in Pakistan because discharge of wastewater is direct into the open sewerage drains, canals, pounds, lakes and rivers without any proper treatment. Faisalabad is the 3rd largest city of Pakistan has population more than 2 million and is well known for having numerous industries pertaining to various sectors. Wastewater of North Western areas of Faisalabad drains into Paharang Drain which eventually discharge into the River Chenab and South Eastern areas drains into Maduana Drain which discharges into Ravi River. Farmers of the countryside mostly use urban municipal wastewater for agricultural purposes because this water has nutrient rich characteristics. Hence, most of heavy metals and petroleum hydrocarbons present in this wastewater which enter into the food chain while irrigation, causing sever health problems to the consumer. For this study, seven locations of Faisalabad including Chakira, Choti 79, Airport, Malkhanwala, Khanowana, Ghutwala and Rasoolpura were selected to assess contaminations in wastewater and analyze the temporal variations in concentrations of heavy metals and petroleum hydrocarbons. To estimate the levels of degradation electrical conductivity (EC), reaction (pH), Heavy metal contents particularly Nickel (Ni), Copper (Cu), Manganese (Mn), Zinc (Zn) and petroleum hydrocarbons were determined. The results showed that the highest pH was observed at Rasoolpura location, highest EC was observed at Airport location, heavy metals (Ni concentration was highest at Airport location, Mn concentration was highest at Choti 79 location, Zn concentration was highest also at Choti 79 location, Cu was maximum at Rasoolpura location) and total petroleum hydrocarbons (TPH) was the leading one at Khanowana site.

Index Terms- Faisalabad, Heavy metals, Peri-urban Wastewater

I. INTRODUCTION

Faisalabad is a third biggest city of Pakistan and it has large number of textile industries (Arshad et al., 2019). There are many industries in Faisalabad which utilized the ground and surface water as a useful resource. Their effluents are responsible for direct pollution of quality of water (Noreen et al., 2017). There are many other anthropogenic activities which might be additionally deteriorating the natural sources of water i.e., fast growing rate of populations, development and social exchange (Vareda et al., 2019). Pakistan may be facing scarcity of fresh water resources and develop into water stressed state. In Pakistan, 82 % of the populations are facing the stress of fresh water, 40% patients are due to water borne diseases and 80% newborns die (Ahmed et al., 2020). Wastewater disposal and effluent coming from industries and municipal cooperation is a very important issue in Pakistan. The wastewater is openly discharged into nearby rivers, canals, open fields, sewer system without any treatment (Manderso et al., 2018). The farmers are making of this wastewater as it carries a number of nutrients. They enter into the soil and surface water reservoirs (Withers et al., 2014). Water is elementary component for all parts of living things. All parts of body are completely made up of complex materials which either suspended or dissolved in water (Giudice et al., 2010). Any human being can stay 40 days without the food however just 4 days without water that is the reason water is suggested as fluid of ways of life (Kumar et al., 2012). Water is ranked as highly essential in human life. It is available in various phases as liquid, solid and gaseous. In solid state, it is in the form of ice of glaciers. The liquid state is as shallow water and ground water. The surface water is in the state of lakes, conductors, drains and seas (Gusyev et al., 2013). The quantity and quality of water from an aquifer depend on the surrounding of the aquifer where the well extracts water. Surface water is formulated as a result of glacier runoff (Askari et al., 2021).

The absorption of the significant metals go into stomach and changed over into their expected oxidation state i.e. As3+. As2+, Cd2+, Ni2+, Pb2+ and are make different bounds with other biomolecules like enzymes and proteins (Bist et al., 2022). When metals enter into the living creatures, they produce many health diseases due to various harmful effect of heavy metals (Al, Cd, Hg, Ni, Cu, and Pb) in human beings e.g., seizures, cardiovascular disarranges, gastric issues, hemoglobinuria loss of development, pneumonia, stomatitis, stun, pain and different others when capricious vapors and gasses are inhaled (Negahdari et al., 2021). Wastewater contains nutrients which are beneficial for plant growth. However, it has very serious health issues due to presence of heavy metals and different constituents (Shaheen et al., 2016). Intake of petroleum hydrocarbons and many heavy metals present in the water has badly affected the health of human beings in many parts of the world. Humans were using vegetables which irrigated by wastewater (Varjani et al., 2017). Some remarkable research has verbalized greater pathogenic pollution in food crops grown

with wastewater (He et al., 2021). Wastewater pollution is one of very common issues of present days. The rapid effect in industrialization has made as the vital effect of water toxic substances. Like oil refinery, pharmaceuticals and agriculture and different others are the key of this kind of contamination (Aylaz et al., 2021). The composition of waste is key component regarding the severity of toxic contamination in soil (Li et al., 2019).

The pH and amount of O2 in wastewater are the indicators of those toxins and quality of water. The use of wastewater for agriculture requires more attention because this extremely affects the health of human. The masses discharged from contaminated soil have negative impact on human prosperity and basic needs (Qiang et al., 2018). In Pakistan, municipal and industrial discharges are dumped into local water bodies are the key contributors of wastewater pollution (Ilyas et al., 2019). It has become a major environmental issue. The studies of World Bank have ranked Pakistan as 17th countries which encounter severe water shortages by 2025. Out of 180 million populations of Pakistanis are deprived of having access to safe drinking water. Asian's water quality ranks 80th out of 120, because of its poor management and monitoring (Sibtain et al., 2021). Only 1% of wastewater is being treated before dumping into local water bodies due to lack of management and regulation authorities (Edokpayi, et al., 2020). Wastewater contains organic as well as inorganic pollutants in which include dyes, Oil hydrocarbons, pharmaceuticals, heavy metals, biodegradable waste, radioactive impurities and other harmful chemicals. Due to water shortage in Pakistan, this polluted wastewater is used for agricultural practices and in this way these pollutants mixed into the soil and ultimately enter the food chain (Lyu et al., 2020). Treatment of contaminated waste was very important for the overall health of community due to several health-related problems. Remediation of contaminated wastewater and soil will have positive impact on soil health and as a result will check the entry of pollutants in the food chain (Pereira, et al., 2021). Soil contaminated with oil hydrocarbons responsible for making a plan to reduce contaminations into the soil. Moreover, petrol hydrocarbons are carcinogenic and when bio accumulated in the food chain can disrupt biochemical activities of many organisms. So, it becomes mandatory to remediate the soil contaminated with petrol hydrocarbons (Ambaye et al., 2022).

II. MATERIAL AND METHODS

Analysis of data of mean sum of squares exhibited highly significant ($P \leq 0.01$) effect of studied traits of targeted locations and timing of wastewater collection (Table 1).

pH

Data regarding pH of wastewater of different sampling dates at different locations showed significant variation (Fig. 2). The maximum pH value was observed at Chakira on 4th June whereas, the lowest pH was measured on 5th of November. Choti-79 had the leading pH value on 24th September and 4th February and the least value was observed on 4th June. However, under Airport and Malkhanwala sites the highest pH was measured on 24th September and 5th November whereas, the least value was found on 18th August and 24th September respectively. Similarly, employed locations Khanowana, Ghuttwala and Rasoolpura reflected the maximum pH on 4th June, 5th November and 18th August and the least value was ensured on 5th November, 4th February and 4th June respectively.

Electrical conductivity

Electrical conductivity of different sampling locations of Faisalabad under different sampling time showed significant response. Fig 3 exposed that the highest EC was determined in Chakira and Choti-79 on 18 August and 4 June respectively while, the lowest EC was recorded on 5 November and 4 February. Airport and Malkhanwala had shown the maximum EC on 18th August, 24th September and 5th November whereas, the minimum electrical conductivity was found on 4th June at Malkhanwala. For EC of Khanowana, Ghutwala and Rasoolpura the maximum EC was measured on 18th August, 5th November and 24th September while the lowest EC was determined on 4th February, 4th June and 18th August respectively.

Copper (mg/L)

Results regarding copper concentration of waste water under different targeted locations of Faisalabad showed significant response. Fig 4 showed that the maximum copper concentration was assimilated on 5th November, 4th June and 4th February in Chakira and Choti-79 while the lowest copper concentration was accumulated on 5th November in Choti-79. Date regarding for copper concentration in Airport, Malkhanwala and Khanowana locations showed that the highest amount of copper was found on 18th August and 4th June sampling time and the least copper concentration was recorded on 18th August in Airport. For Ghutwala and Rasoolpura location the maximum copper concentration was recorded on 24th September and 4th June and the minimum copper concentration was resulted on 4th February in Ghutwala site.

Zinc (mg/L)

Statistically significant variation of zinc concentration in waste water was showed under different locations and sampling time (Fig. 5). Under Chakira, Choti-79 and Airport exposed that the highest zinc concentration was resulted on 5th November, 4th February and 4th June in Choti-79, Chikara and Airport locations respectively whereas, the minimum zinc amount was assimilated on 4th November in Airport sampling location. Malkhanwala, Khanowana, Ghutwala and Rasoolpura exposed that the highest concentration was recorded in Malkhanwala, Khanowana, Ghutwala and Rasoolpura on 4th June, 5th November, 24th September respectively whereas, the least value was documented on 18 August in Rasoolpura followed by 18th August in Ghutwala and 4th June in Khanowana.

Manganese (mg/L)

Data regarding manganese concentration in wastewater of different sampling locations of Faisalabad under different sampling time showed significant variation (Fig. 6). At Chikara, Chot-79 and Airport significantly the highest manganese concentration was observed on 4th June, 24th September and 18th August respectively whereas, the least value was determined under Airport site dated 4th February. Moreover, the significantly Mn concentration was exhibited under Malkhanwala on 5th November and Khanowana on 4th June while, the minimum amount was reveled on 4th February of Khanowana. Ghutwala and Rasoolpura sites resulted the leading concentration on 4th February and 18th August respectively and the minimum Mn was determined on 4th June and 24th September of respective sites.

Nickel (mg/L)

Results regarding nickel concentration in wastewater under different locations of Faisalabad showed significant variation. Fig 7 showed that the maximum nickel concentration was recorded in Chakira and Choti-79 on 4th June, 4th February and 5th November respectively whereas, the least nickel value was assessed in Choti-79 on 18 August. Airport, Malkhanwala and Khanowana revealed the maximum concentration on 18th August, 24th September and 4th June respectively and the lowest value was assimilated on 4th June in Airport site. Under Ghutwala and Rasoolpura, the maximum amount was accumulated on 24th September, whereas the lowest concentration was resulted in Rasoolpura on 4th June and 5th November in Ghutwala.

Total Petroleum Hydrocarbons (mg/L)

Results showed that the maximum total petroleum hydrocarbon was determined in Chakira and Choti-79 on 5th November and the lowest amount was recoded on 18th August and 5th November (Fig. 8). For total petroleum hydrocarbon under Airport, Malkhanwala and Khanowana locations were identified for the maximum total petroleum hydrocarbon on 4th June, 5th February and 24th September respectively and the least TPH was found on 24th September in Airport. Moreover, total petroleum hydrocarbon of Ghutwala and Rasoolpura unveiled the maximum total petroleum hydrocarbon on 5th November and 4th February respectively.

Biplot analysis

Biplot analysis was performed of selected locations and timing of sample collection of studied traits such as pH, EC, Cu, Zn, Mn, Ni and TPH (Fig. 9). Biplot diagram was categorized in to four comments i.e., 1st component consist of Zn and Mn, 2nd contain of Ni and TPH, 3rd comprise of EC and 4th showed Cu and pH. Diagram had shown the maximum Zn concentration of employed treatments L2×T3 and L2×T2. Similarly, the highest content of Mn was exposed under L3×T3 treatment whereas, the leading Ni and was found from L4×T3 treatment. However, 3rd group and treatment L6×T4 depicted the highest EC as well as 4th component resulted the leading pH of L3×T1 and L1×T1 treatments.

DISCUSSION:

In this study the results showed that highest EC was observed at Rasoolpura location and lowest values was observed at Khanowana location. The variations in EC were due to location's contaminations and follow rate of different contaminations from industries in different periods of time and also due to variations in temperature affected the ions concentration in wastewater (Tansel et al., 2018; WWF, 2008; Murtaza et al., 2008). The highest pH was recorded at Airport location and lowest pH was observed at Ghutwala location. In this all-locations pH was found in acidic in nature. The variation was due to different kinds of discharge in wastewater by different industries of Faisalabad (Bhatia et al., 2018). The concentrations of heavy metals in mg/L were determined from all locations of sampling sites the highest concentration of Ni was recorded at Airport location while lowest concentration of Ni was found at Khanowana location. Therefore, the highest concentration of Mn was recorded at the location of Choti 79 and lowest concentration of Mn was found at the Airport location, the highest concentration of Zn was found at Choti 79 location and lowest concentration of Zn was observed at Rasoolpura location, the highest concentration of Cu was observed at Rasoolpura location and lowest concentration at Chakira location was observed. In this present study total petroleum hydrocarbons (TPH) were observed highest concentration at Khanowana location while lowest concentration was found at Chakira location. The variations in concentration in TPH were due to location's contaminations, different temperatures and different follow rates of discharge of textiles industries of Faisalabad during different seasons of year. Similar observations were cited by Younas et al. (2022).

III. CONCLUSION

This study was aimed to evaluate monthly variations of the effluents discharge limits for pH, EC, heavy metals (Ni, Zn, Mn and Cu,) and total petroleum Hydrocarbons (TPH), proposed by Pakistan National Environmental Quality Standards (Pak-NEQS) and determine the most cost-effective treatment alternative that would allow the all types of industries of Faisalabad to meet proposed discharge limits.

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Table-1 Mean sum of square of studied traits i.e., pH, EC = electrical conductivity ((µS/cm), Cu = Copper (mg/L), Zn = zinc (mg/L), Mn = manganese (mg/L), Ni = Nickel (mg/L) and TPH = total petroleum hydrocarbons of different locations and time

		Mean sum of square						
SOV	DF	pH	EC	Cu	Zn	Mn	Ni	TPH
Location (L)	6	0.22**	681.43**	0.0021**	0.007186**	0.0058**	0.0074**	459.1**
Time (T)	4	4.52**	930.07**	0.0073**	0.006855**	0.0041**	0.0068**	451.4**
LxT	24	0.30*	308.83*	0.0032**	0.007853**	0.0161**	0.0029**	40.6**
Residual	70	0.00	0.45	0.0001	0.000002	0.0002	0.0001	0.1**
Total	104							

Here, ** denoted highly significant (P≤0.01) and * significant (P≤0.05)

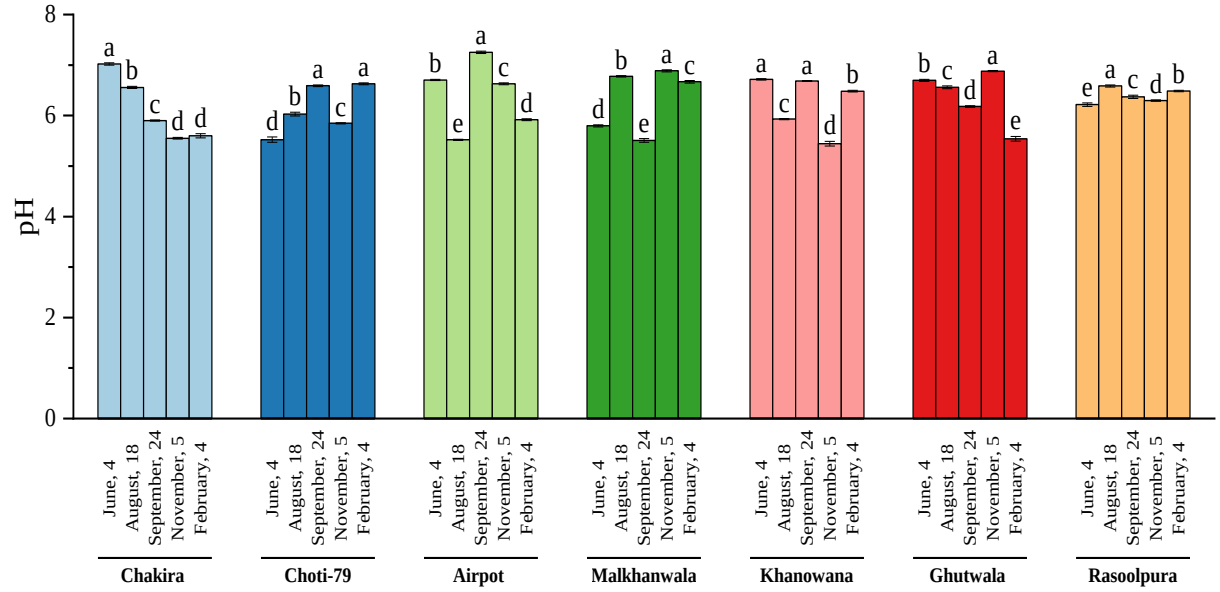

Fig.2. Response of pH under different locations and varying timing of wastewater collection of Faisalabad region. Similar letters showed insignificant (P≥0.05) response of respective treatments

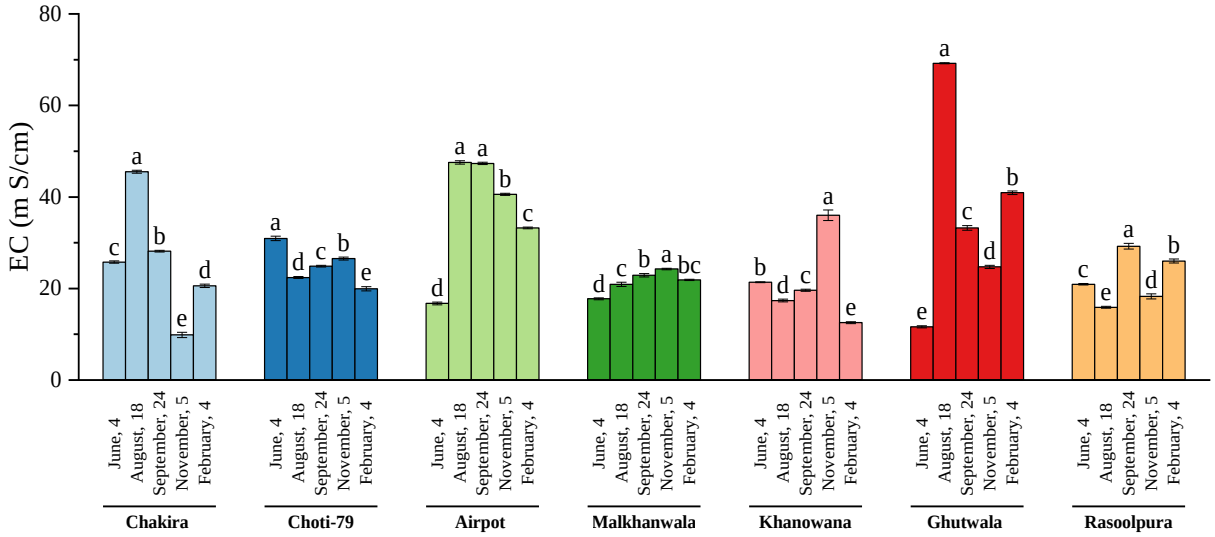

Fig.3. Response of EC under different locations and varying timing of wastewater collection of Faisalabad district. Similar letters showed insignificant (P≥0.05) response of respective treatments

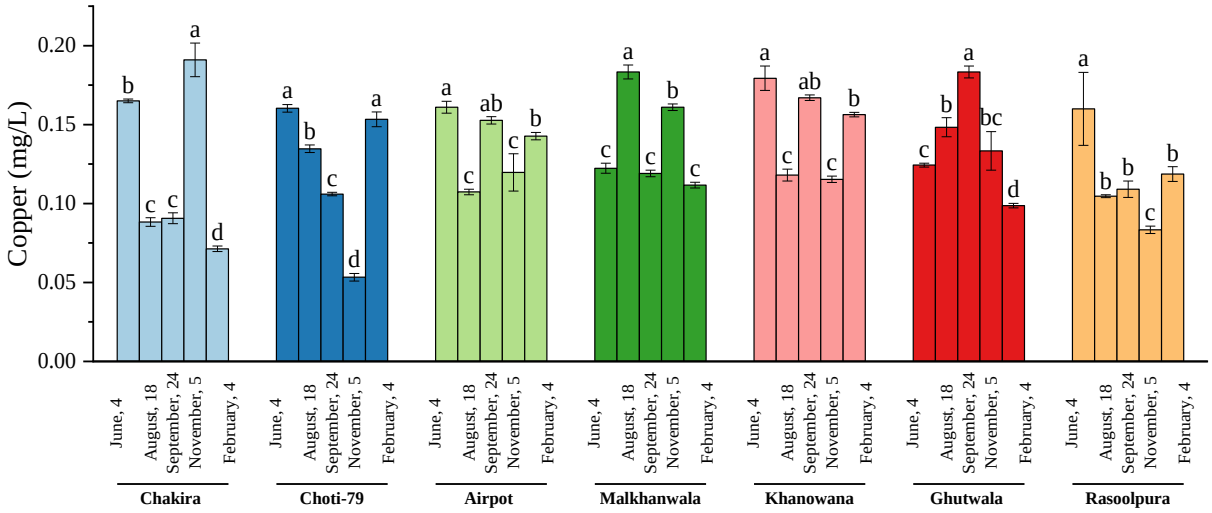

Fig.4. Response of copper under different locations and varying timing of wastewater collection of Faisalabad district. Similar letters showed insignificant (P≥0.05) response of respective treatments

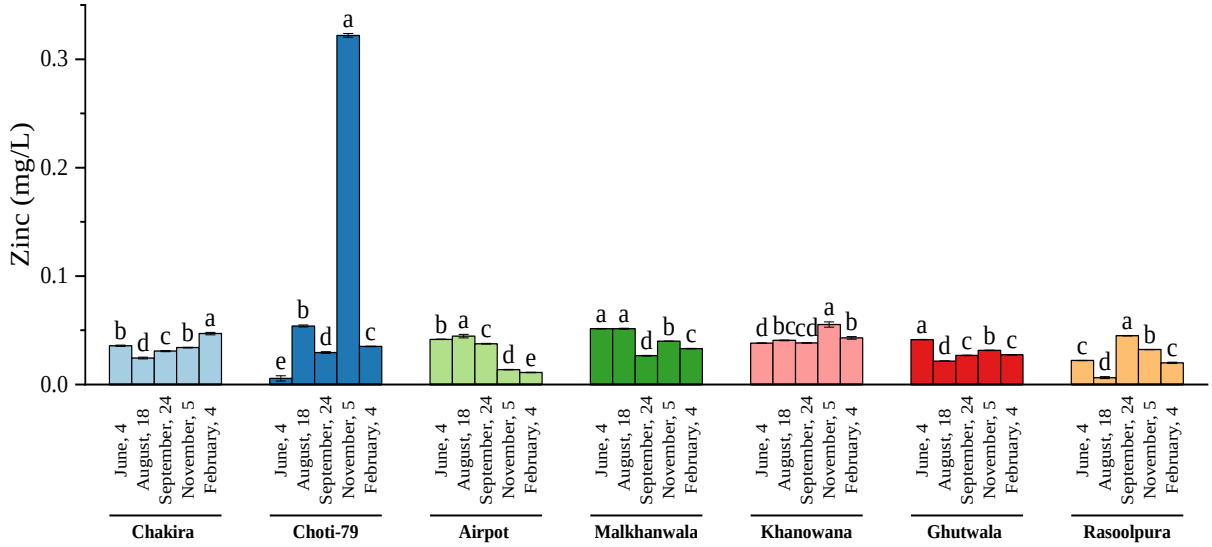

Fig.5. Response of zinc under different locations and varying timing of wastewater collection of Faisalabad district. Similar letters showed insignificant (P≥0.05) response of respective treatments

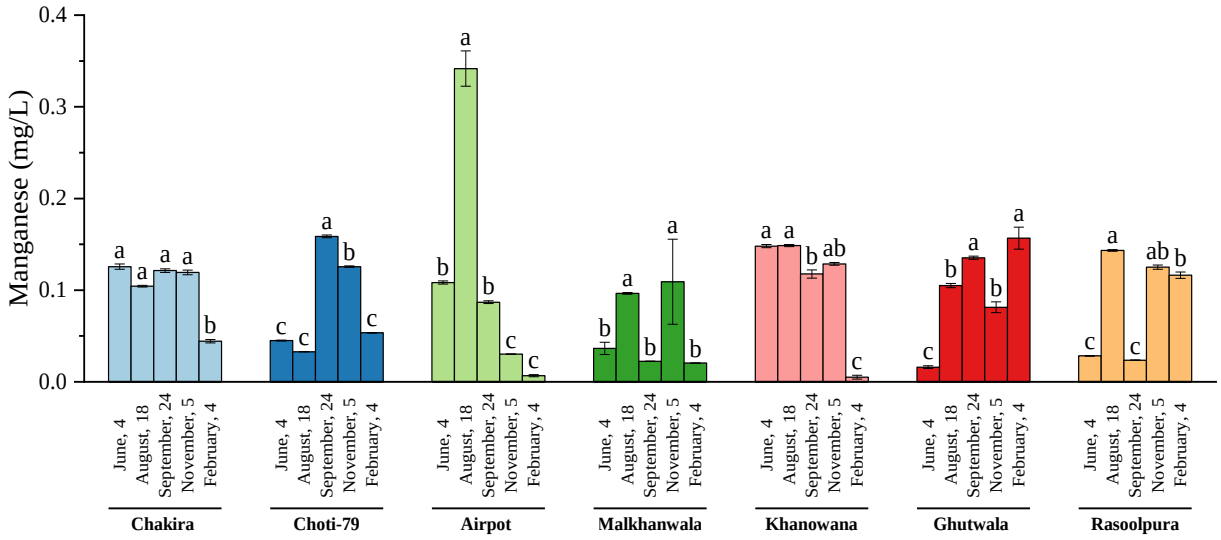

Fig.6. Response of manganese under different locations and varying timing of wastewater collection of Faisalabad district. Similar letters showed insignificant (P≥0.05) response of respective treatments

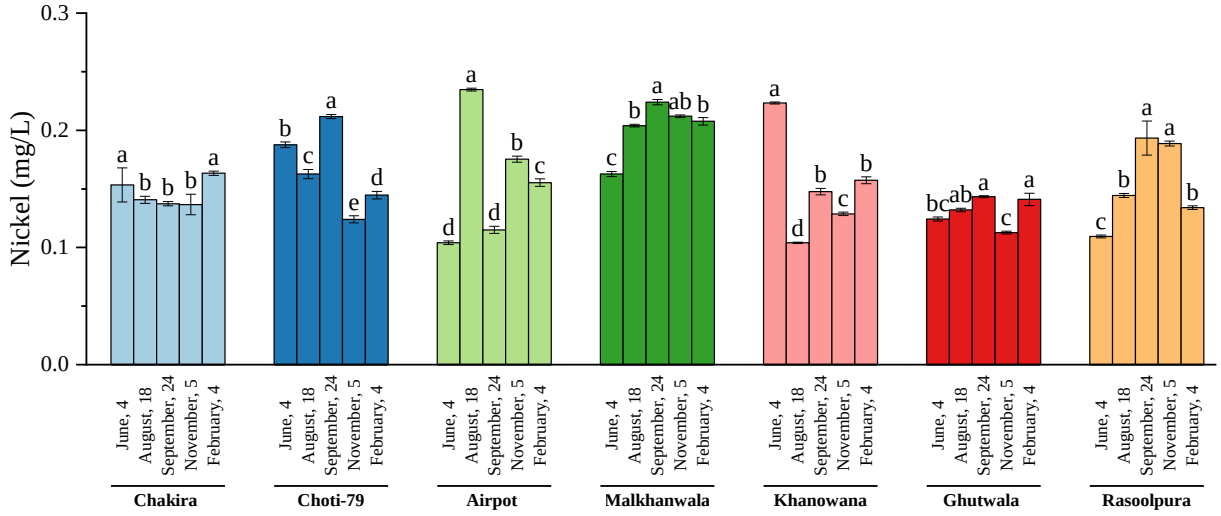

Fig.7. Response of nickel under different locations and varying timing of wastewater collection of Faisalabad district. Similar letters showed insignificant (P≥0.05) response of respective treatments

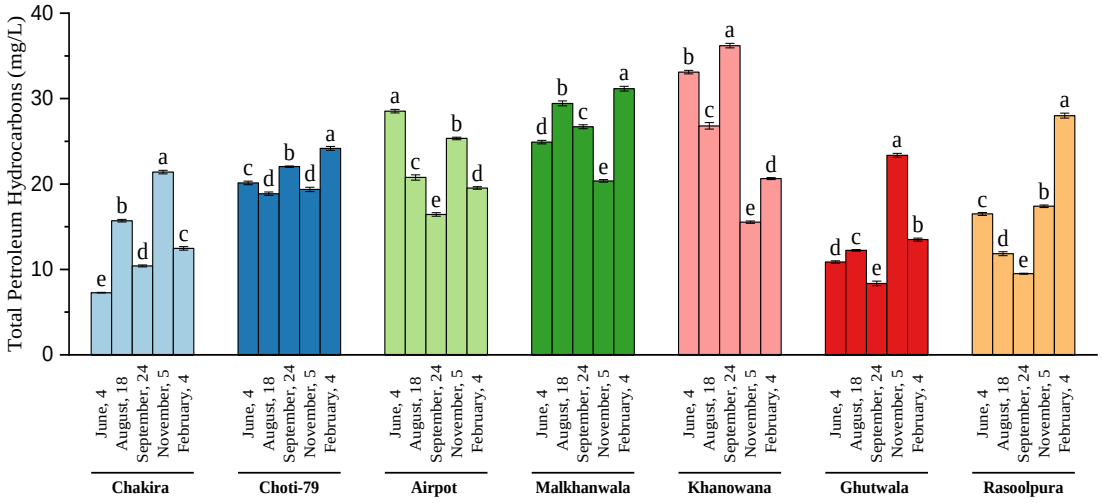

Fig.8. Response of total petroleum hydrocarbon under different locations and varying timing of wastewater collection of Faisalabad district. Similar letters showed insignificant (P≥0.05) response of respective treatments

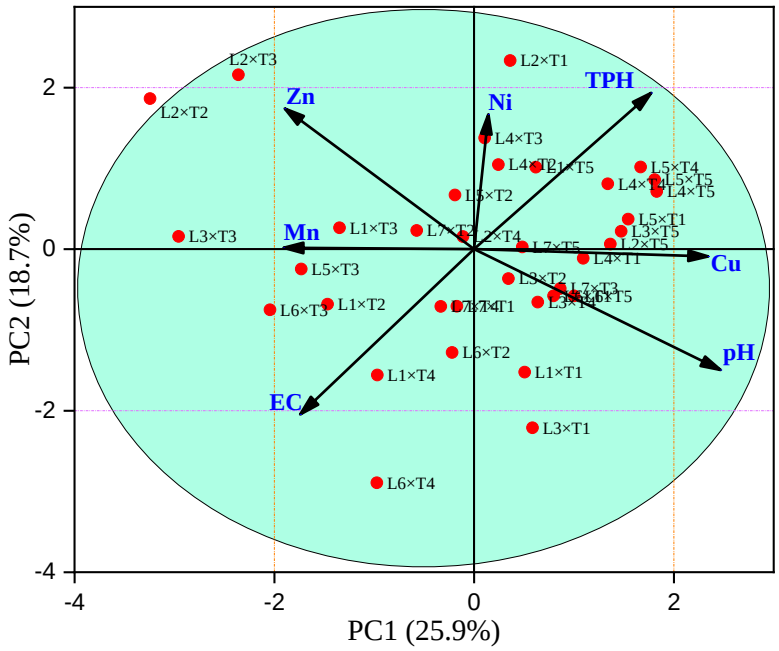

Fig.9. Biplot analysis of heavy metals of different locations and timing of wastewater collection of Faisalabad district. Here L1 = Chakira, L2 = Choti-79, L3 = Airport, L4 = Malkhanwala, L5 = Khanowana, L6 = Ghuttwala and L7 Rasoolpura and T1 = 4th June, T2 = 18th August, T3 = 4th September, 4 = 5th November and T5 = 4th February